STUDY GUIDE FOR
RIGHT-OF-WAY WEED CONTROL

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about this pest-control subject or your pest-control profession. It will, however, help you prepare for your test.

Contributors include the Utah Department of Agriculture and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State University Extension Service. Other contributors include: Extension Service personnel of California, Kansas, New York, Oregon, Pacific Northwest, Pennsylvania, and Wyoming. Other contributors were the U.S. Department of Agriculture -- Forest Service; the U.S. Environmental Protection Agency (Region VIII), the Department of Interior -- Bureau of Reclamation, and Metro Pest Management.

The information and recommendations in this study guide are based on data believed to be correct. However, no endorsement, guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

Other topics that may be covered in your tests include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators*. U.S. EPA, USDA and Extension Service, revised 1991.

2. *Applying Pesticides Correctly: A Supplemental Guide for Private Applicators.* U.S. EPA, USDA and Extension Service, December 1993, Publication E-2474.

These books can be obtained from the Utah Department of Agriculture or Utah State University Extension Service. Please contact your local Utah Department of Agriculture field representative or Utah State University extension agent.

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INTRODUCTION

It's very often both desirable and advantageous to control vegetation in waste or idle land sites.

These sites may include parking lots, driveways, power lines, around buildings, along roadsides, and in many other right-of-way areas.

Weed control is accomplished by various means of vegetation management. The course of action is dependent on the objective. There are many reasons to control weeds and brush. A few obvious reasons are fire safety, automobile safety, and wildlife conservation.

Industrial and right-of-way weed control is a major concern to many Utah people. The control of pest weeds, grasses and brush in the kind of sites mentioned often involves the use of herbicides.

This study guide deals primarily with this aspect of weed control on industrial and right-of-way sites.

PLANNING

The objective of industrial and right-of-way vegetation management is to maintain a definite type of cover or bare ground. Consider the type and species of vegetation present and what type and species, if any, are desirable. Once you make this decision, you can plan a management program.

Rights-of-way are the areas involved in common transport. Included are:

- Federal, state, county, and township highways and roads
- Public airports
- Railroads
- Electric utilities (including transformer stations and substations)
- Pipelines (including pumping stations)
- Public surface drainage ways
- Public irrigation waterways
- Bicycle, bridle, snowmobile, and other public paths or trails

Plant growth along the right-of-way must be controlled to make sure the right-of-way is:

- Safe
- Usable
- Attractive
- As inexpensive as possible to maintain
- Not harmful to the environment or the surrounding area

VEGETATION MANAGEMENT

Consider what vegetation already exists along the right-of-way and what may need to be added. Usually, grasses should predominate, but some legumes may be desirable. For added beauty and variety, encourage some wildflowers. Also, consider shrubs with colorful fruit and berries. Plants along a right-of-way that can be considered weeds are those that:

- Are a safety hazard.
- Are a nuisance.
- Are unsightly.
- Impede the use and maintenance of the right-of-way.
- Cause injury to man or animals.
- Have been legally declared "noxious."
- Crowd out desired plants.
- Damage structures such as road surfaces and rail ballast.
- Could harm adjacent crops if allowed to spread.

A plan for controlling plant growth along a right-of-way may include mechanical, cultural, biological and chemical methods. All the control methods should be coordinated, since each has an effect on the others.

MECHANICAL METHODS

These include:

- Erosion prevention and cover establishment
- Planting and encouraging desirable species
- Using competitive characteristics of desirable plants
- Mowing
- Landscaping
- Controlled burning
- Hand-removal of undesirable plants
- Total removal and replacement

CHEMICAL METHODS
These include:

- Fertilization
- Herbicides
- Growth regulators

WEED PLANTS
A weed is simply a plant growing where it isn't wanted. There are many species of plants in Utah that may be considered as weeds in industrial and right-of-way sites.

TREATMENT NEXT TO SENSITIVE OR OTHER DESIRABLE VEGETATION
It can't be emphasized enough to applicators who spray along public roads or railroads that sensitive crops, shrubs, trees or vines can be damaged unintentionally. Spray operators should be aware that trees can have a root spread underground of up to three times the height of the tree. A 50-foot shade tree could have roots as far as 150 feet away from the main trunk. The spray applicator should shut off the sprayer a safe distance from the non-target vegetation and spot-spray later with a chemical that is safe to use.

Some field or orchard crops are more sensitive to chemicals than others. Potatoes, tomatoes, curcurbits, grapes and peppers are extremely sensitive to the phenoxy sprays. A chemical such as Oust may ruin entire potato fields if conditions are right. In most instances, the label will have a warning and list crops that are especially sensitive to a particular herbicide.

Again it should be emphasized that with any herbicide treatment, whether industrial weed control or right-of-way applications on highways, the adjacent crops' susceptibility to damage must always be a consideration.

A successful weed-management program depends on identifying the weed(s) and understanding their basic life cycles. This often requires the help of a specialist.

COMMON LIFE CYCLES OF WEEDS

PLANTS

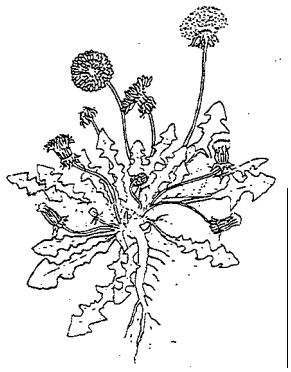
Plants can be classified according to their life cycles as annuals, biennials or perennials. These are not strict botanical divisions, but they are groupings that are important in determining how to control the plants.

ANNUALS mature in one season and are propagated by seeds. Summer annuals grow from seeds that sprout in the spring, mature, and reproduce before dying in the winter. Among the common summer annuals are barnyard grass, puncturevine, Russian thistle, and pigweed.

WINTER ANNUALS germinate in the fall or winter and grow until spring, when they flower, produce seed and die. Among the common winter annuals are chickweed, mustard, wild oats, downy brome, and annual bluegrass.

BIENNIALS require two years to develop and complete their life cycles. These plants grow vegetatively (without flowering) through the first year. In the second year, the plant flowers, produces seed, and generally dies. Common biennials are mullein, musk thistle, poison hemlock, and hounds-tongue.

PERENNIALS are plants that live three years or longer. These plants flower and set seed without dying. They live indefinitely; they may lose their foliage during the winter and die back to the ground, but they recover in the spring. Common examples are leafy spurge, Russian knapweed, field bindweed, willow, and poison oak.



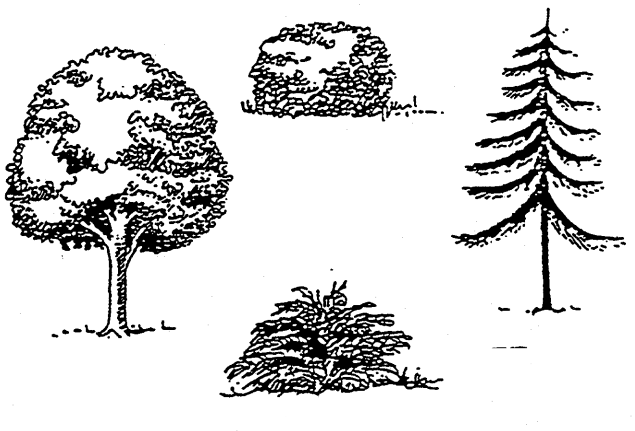
Perennial plants are members of many major plant groups, and they may take many forms. Some are

herbaceous, soft-bodied plants; other are shrubs; and some are fully developed woody trees. Many perennials store food under-ground in rhizomes, bulbs, roots or tubers, which make these plants hard to kill mechanically or chemically.

COMMON FORMS OF WEEDS

While there are a great many species of weeds, most may be placed into one of five convenient groups: grasses, grasslike sedges, grasslike rushes, forbs and shrubs. The chart below demonstrates the differences between the groups. Knowing the type of plant and the species is important to obtain control.

Woody plants are further divided into shrubs and trees.



Deciduous *Shrubs* *Evergreen*

Shrubs usually have multiple stems and are less than ten feet tall, while trees usually have a single stem (trunk) and are usually more than ten feet tall. Shrubs also form an understory when found with trees.

CLASSIFICATION OF HERBICIDES

BY CHEMICAL GROUP

Devising a simple classification scheme for herbicides is hard because many kinds of chemicals are used as herbicides, and while they are formulated in ways similar to the insecticides, they exhibit a variety of modes of action. To classify herbicides by chemical group requires at least 20 different categories, only a few of which will be mentioned here.

INORGANIC HERBICIDES are chemical compounds that don't contain carbons. The inorganics include such common materials as salt, copper sulfate, sulfuric acid, and sodium chlorate. These herbicides are extremely persistent and have caused serious soil-pollution problems in some areas. Many are restricted materials.

ORGANIC HERBICIDES may be divided into two major groups -- the petroleum oils and the synthetic organic herbicides.

PETROLEUM OILS are refined from crude oil and can be used as either herbicides or insecticides. When formulated as herbicides, they are applied without dilution.

SYNTHETIC ORGANIC HERBICIDES are made up of carbon, hydrogen, often nitrogen, and other elements. One of the most common synthetic organic herbicides is 2,4-D.

BY USE

Herbicides may be conveniently classified by use, which is, whether they are applied to the soil or foliage, and by their selectivity, which is, how they affect the target plant. (Herbicides may also be classified according to their modes of action, although this classification scheme isn't used very often.)

SELECTIVE HERBICIDES are used to control certain weed species without injuring desirable plants. Even the best herbicides are only relatively selective and can damage or kill the desired plants as well as the weeds, if misused.

Foliage-applied selective herbicides are applied to the leaves and other above-ground parts of the plant. Once applied, they may kill only the parts of the plant

actually sprayed. In this case, they are considered contact herbicides. Complete weed-kill using contact herbicides requires well-directed and properly applied sprays. Complete coverage of the weed is a must. Selectivity often depends on differences in coverage when spraying: for example, some herbicide formulations wet broad-leaved plants and run off of grasses.

Soil-applied selective herbicides are applied to the ground and may be recommended for use for pre-plant, pre-emergence, post-emergence or other treatments. These herbicides are generally incorporated into the soil by mechanical means such as tilling or by water from irrigation.

TRANSLOCATED HERBICIDES are applied to the leaves and move systemically into the other parts of the plants, causing complete kill. Selectivity of the translocated herbicides depends on differences in the biochemistry of plant species; some plants are poisoned and others are not.

NON-SELECTIVE HERBICIDES kill most plants when applied. These herbicides are used when complete removal of vegetation is desired, such as along highway rights-of-way. Non-selective herbicides can be applied to foliage as contact herbicides or as translocated herbicides. They may also be applied to soils, where they kill nearly all plants growing there. Some soil-applied herbicides are available as fumigants.

BY EFFECT

Herbicides can be classified by how they affect plants. Most herbicides will have several different types of effects which determine when and how they can be used. The application should be in a uniform pattern at rates recommended on the label.

SELECTIVE HERBICIDES

Selective herbicides are chemicals that are more toxic to some plant species than to others. Plants must be correctly identified and the proper chemical applied at the right rate and time. Examples are 2,4-D; picloram and dicamba.

NON-SELECTIVE HERBICIDES

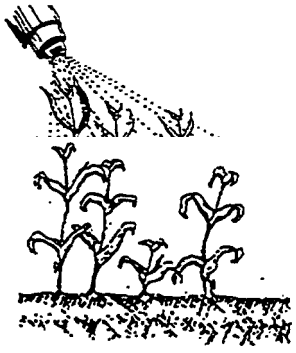
Non-selective herbicides are chemicals that are generally toxic to plants without regard to species. Toxicity may be a function of rate, method of application, and other factors. They may be used to provide bare ground area to reduce fire or safety hazards, improve line of sight, protect structures from damage, eliminate breeding areas for rodents and insects, and improve security. Examples are bromacil, diuron, and paraquat.

Wind, water and soil erosion can cause herbicides to move sideways after application and before the chemical is fixed in the soil. Be careful to prevent surface movement, which could cause damage to desirable plants in adjacent areas. Herbicides seldom move off target when applied to ballast and pavement cracks.

Non-selective herbicides usually should not be applied to slopes greater than six-to-one unless the ground is protected from erosion.

CONTACT HERBICIDES

Contact herbicides are chemicals that cause localized injury to plant tissues where contact occurs. They must be applied when the plants are leafed out and growing. Good coverage with the spray solution is necessary, since only those areas covered are controlled. Most contact herbicides are non-selective. Examples are paraquat and diquat.



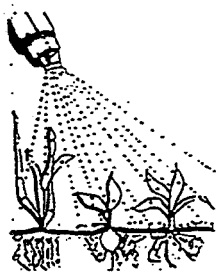
Spraying of visible plant foliage starts the action of a contact herbicide. A sprayer is usually used to apply herbicide after growth has started.

Herbicide is taken into the plant leaves, where it interferes with growth. The plant begins to curl, wither, and then turn brown.

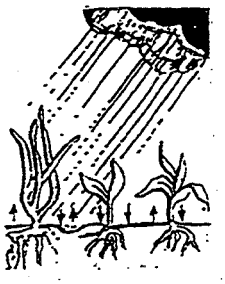
Weed growth above ground is eliminated. Some weeds won't come back. However, some weeds may regrow from roots. New weeds may grow from seeds in the soil.

TRANSLOCATED HERBICIDES

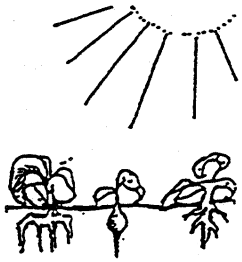
Translocated herbicides are chemicals that are moved within the plant. Most are selective. Some are effective when applied to the plant foliage, while others are effective through root uptake from soil application. Length of control is determined by chemical used, rates applied, rainfall, and soil type. Examples are 2,4-D; picloram; bromacil; and dicamba.



Apply to soil and young plants in early spring.



Rain washes herbicide into the soil. It dissolves and is absorbed by the plant.



Herbicide is translocated to growing points. Plant yellows and gradually dies.

Plants die and ground may remain bare for a year or more.

PLANT-GROWTH REGULATORS

Plant-growth regulators are substances for controlling or modifying plant-growth processes without appreciable phytotoxic effect at the rate applied, either to themselves or other species. They are generally applied to the foliage and don't have soil persistence. Because they don't create bare ground, they help prevent erosion. An example is fosamine ammonium.

PRE-EMERGENCE HERBICIDES

Pre-emergence herbicides are chemicals that are applied prior to emergence of the species to be controlled. These are generally soil-applied and are translocated into the plant through root uptake. Examples are picloram, bromacil, trifluralin and dacthal.

POST-EMERGENCE HERBICIDES

Post-emergence herbicides are chemicals that are applied after emergence of the species to be controlled. These are generally foliar-applied and are contact or translocated herbicides. Examples are 2,4-D; paraquat; glyphosate; and dicamba.

SOIL STERILANTS

The use of herbicides on industrial and right-of-way areas often involves the use of soil sterilants that control all vegetation for extended periods of time. Soil sterilization can be especially beneficial before laying blacktop or gravel for driveways or parking lots. Soil sterilants can be used along roadsides, guard rails, bridge abutments, fence lines, and railroad sidings.

Since the potential for environmental and off-site damage from soil sterilants is high, the following section deals with soil-sterilant-type herbicides.

NON-SELECTIVE SOIL-STERILANTS

Soil-sterilant- type herbicides (compounds that persist in the soil) are effective against a wide range of annual and perennial weeds; however, they vary in their persistence, and none are effective against all vegetation at economical rates. For example, when used at relatively low dosages, triazines are weak against pigweed and salt-tolerant grasses. The substituted-urea herbicides also are weak on some grasses and are relatively ineffective against established perennial broadleaf weeds, except at high rates.

A soil sterilant may be defined as a compound when applied to the soil; it prevents the establishment of vegetation ranging from a short time to relatively long periods of time.

Temporary Soil Sterilants are effective for one year or less. They are used mainly to kill annual weeds on agricultural land that is to be returned to production.

Permanent Soil Sterilants provide complete and long-lasting destruction of all plant growth. The length of sterilization will depend on: (1) susceptibility of the weeds to specific chemicals; (2) nature of the soil; (3) rainfall or other moisture in the area; and (4) properties of the chemical.

SOLUBILITY

The water solubility of a soil-persistent herbicide has a definite effect on the length of time the herbicide will persist and remain active in soil. The lower the solubility, the greater the amount of precipitation it takes to activate the chemical and the longer it will persist in the weed-germinating zone.

The degree to which a residual herbicide is absorbed by soil particles will also determine the time it will remain effective and prevent growth of vegetation. The more highly absorbed, the longer the residual.

PHOTO-DECOMPOSITION

In the winter months during periods of low sunlight intensity, the breakdown of soil-persistent herbicides from ultraviolet rays is less than during the summer. Incorporating the herbicide into the soil after application, along with added moisture or mechanical incorporation, will reduce photo- decomposition.

SOIL FACTORS

Soil type is a very important factor in determining the rate of herbicide needed and length of time the herbicide will persist. It's also an important factor in safety to adjoining desirable vegetation. Lighter- textured soils (sandy soils) usually require lower rates for vegetation control; however, persistence of the chemical may be shorter. Heavier-textured soils require higher rates.

Clay soils high in organic matter have greater retention capacity for organic herbicides than do sandier soils. One cubic foot of clay has the absorptive capacity of 350 cubic feet of sand. Soils very high in organic matter (peat soils or burned-over areas) may so completely absorb organic herbicides to make them ineffective. This is especially true of the triazines and ureas. The uracils are less susceptible to complete deactivation.

All organic herbicides are broken down to some degree by soil organisms. This action is faster in high-fertility soils due to the presence of more bacteria.

MOISTURE FACTORS

All persistent herbicides will perform more satisfactorily if applied to moist rather than dry soil. Wind erosion and movement of the chemical can also result when it's applied to dry, dusty soils.

Best results will be obtained when application of a soil-persistent herbicide is followed by two to three inches of rain, allowing the soil to dry and the herbicide to be fixed on the soil particles before additional rain occurs. Long periods of rain can reduce the effectiveness of the herbicide by leaching. Areas of high rainfall will generally require higher rates of chemical for desirable results.

PLANT FACTORS

Some plants have "built-in" tolerance for certain herbicides. This is usually pointed out on the label, along with mention of which plants the herbicide is most effective on.

WHEN TO APPLY

Usually the best time to apply permanent soil-sterilant-type herbicides is in late fall or early winter to insure leaching of the herbicide into the weed-seed zone by spring. A moist soil surface is ideal for late-fall or early-winter applications. The more soluble, temporary soil sterilants can be applied in the early spring before weeds and other vegetation start to grow.

SHORT-AND LONG-TERM CONTROL

When single-season control of annual weeds is desired, use a short-residual herbicide, which should disappear from the soil in one season. This is the type of herbicide most commonly used on vacant lots, along highways or roadways adjacent to desirable vegetation or where future landscaping may be made, city streets and alleyways, and
fence lines.

Herbicides used on industrial sites are most often classified as the permanent type, so they can provide long-lasting vegetation control. These include the triazine and substituted-urea compounds.

PRECAUTIONS WHEN USING HERBICIDES WITH MEDIUM TO LONG SOIL PERSISTENCE

1. Understand the characteristics and limitations of the herbicide, and take necessary precautions. The greatest danger in the use of soil-sterilant herbicides is damage to desirable plants. Some of these herbicides are very deadly to trees and shrubs, and tiny amounts will kill desirable plants as well as weeds. Always use the chemical that is safest for the area where it's to be applied. Leave a "buffer" or "safety zone" between the treated area and desirable plants. Some of these herbicides should be used only where there are no desirable plants for a considerable distance; others can be used with a fair amount of safety near trees, shrubs, or desirable plants. Some compounds are more soluble than others and leach into the soil with relatively little horizontal movement. Some will last only one year, while others may persist in the soil for two or more years. Know what you buy, and know what it will do after you apply it.

2. Don't apply soil sterilants over the root zone of desirable plants. Determine the root spread of trees and shrubs near the treated area. Roots of trees and shrubs will sometimes extend at least four times their height. Also, don't apply soil sterilants to soil in which roots of desirable plants may grow.

3. Don't apply these chemicals in areas where they may be carried with runoff water from rainfall or irrigation or into soil where desirable plants are growing or may be planted later.

4. Apply these chemicals in such a manner that they won't be moved by wind. Incorporate them into the soil, soon after application, with water or by mechanical means. Some granule-type herbicides are more likely to move than liquid or wettable-powder formulations.

5. Once a soil sterilant has been applied and mixed with the soil, there is no quick way to remove it or neutralize its effect. Replacing the treated soil will help. Charcoal mixed with the treated soil will tie up and absorb part of the chemical. Diking around treated areas and flooding with water will help to leach water-soluble sterilants but may not help much with the more permanent types.

6. Plan carefully and follow directions. The decision to use soil sterilants should be weighed carefully. When properly used, soil sterilants can save valuable time, labor, and expense.

FACTORS AFFECTING HOW HERBICIDES WORK

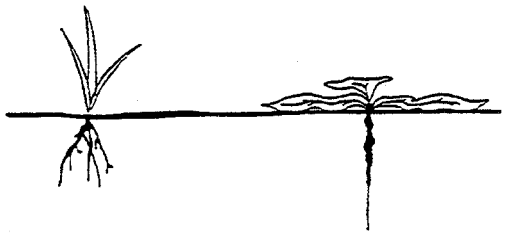
STAGES OF GROWTH

Grasses and broadleaf weeds go through four stages of growth:

- Seedling
- Vegetative
- Bud and flowering
- Maturity

Seedling

The seedling stage of growth is the same for annual, biennial and perennial weeds. They are all starting from seed. The weeds are small and tender, so less energy is required for control at this stage of growth than at any other stage. This is true, whether mechanical or chemical control is used. Herbicides with foliar and/or soil activity are commonly used and are usually effective at this stage.



Grass *Broadleaf*

ANNUALS AND BIENNIALS

Vegetative

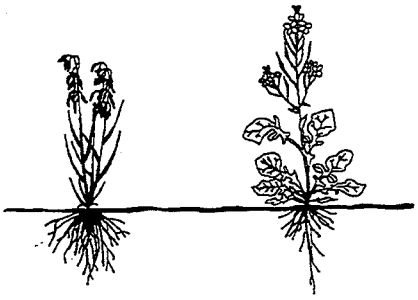
During the vegetative stage of growth, energy produced by the plant goes into the production of stems, leaves and roots. Control at this stage is still possible but sometimes harder than at the seedling stage of growth. Cultivation, mowing, and post-emergence herbicides are effective controls.

VEGETATIVE (ANNUALS)

Bud and Flowering

When a plant changes from the vegetative to the flowering stage of growth, most of its energy goes into the production of seed. As plants reach this more mature stage, they are usually much harder to control by either mechanical or chemical methods.

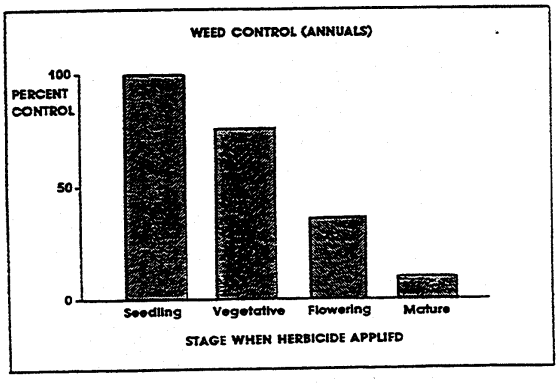
FLOWERING (ANNUALS)



Grass *Broadleaf*

Maturity

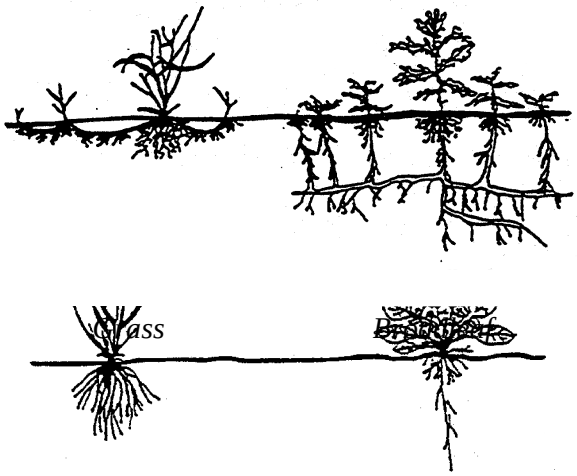
Maturity and seed set of annuals completes the life cycle. Chemical control is usually not effective at this stage, since there is little or no movement of materials in the plant. Once the seeds are mature, neither mechanical nor chemical controls can harm them.



PERENNIALS

Vegetative

When the plant is small, part of the energy used to produce stems and leaves comes from energy stored in the underground roots and stems. As the plant grows, more energy is produced in the plant leaves. Some of this is moved to the underground parts for growth and storage. Herbicides usually provide good control at this stage.

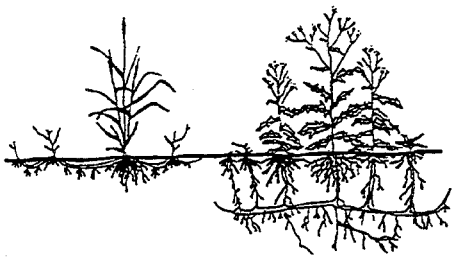


Grass *Broadleaf*

Bud and Flowering

At this stage, the plant's energy goes into the production of flowers and seeds. Food storage in the roots begins during these stages and continues through maturity. Chemical control is more effective at the bud stage than at the flowering stage. Chemical control during the flowering stage may reduce the viability of the seeds.

FLOWERING (PERENNIALS)

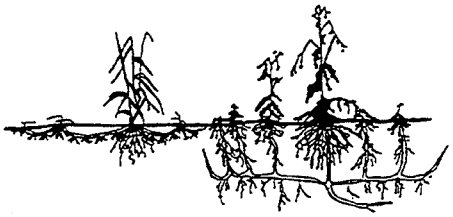


Grass *Broadleaf*

Maturity

Only the above-ground portions of these plants die each year. The underground roots and stems remain alive through the winter and send up new plant growth the next spring. Chemical control is usually less effective at this stage.

MATURITY (PERENNIALS)



Grass *Broadleaf*

Chemical control has been found to be very effective in the fall, when the plant is mature and starting to go dormant for the winter.

WOODY PLANTS

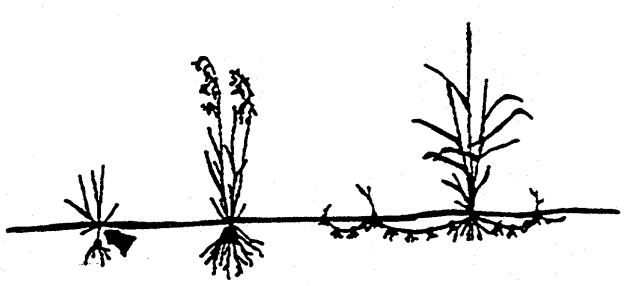
Woody plants go through the same four growth stages as other perennial plants. They don't die back to the ground during the winter, but deciduous trees lose their foliage. Woody plants can be controlled with herbicides at any time, but control is best when the plants are small. Foliar
treatments can be used at any time when the woody plants have actively growing leaves. They usually work best as the leaves reach full size. After a first frost in the fall is also a very good time for chemical control on woody plants.

FACTORS AFFECTING FOLIAGE APPLICATION

LOCATION OF GROWTH POINTS

The growing point of a grass seedling is protected below the soil surface until seed stalks are produced. The plant will grow back if the herbicide or cultivation doesn't reach the growing point. Creeping perennial grasses have buds below the soil surface.

GRASS

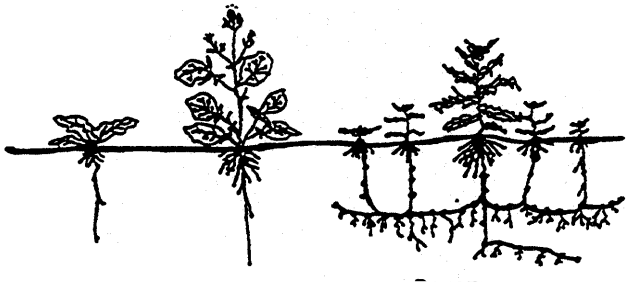


Seedling *Annual* *Perennial*

Many woody plants, either cut or uncut, will sprout from any point where buds are found. These include roots, collar (base of trunk), trunk, or stem and limbs.

Seedling broadleaf weeds have an exposed growing point at the top of the young plant. They also have growing points in the leaf axils. Herbicides and cultivation can reach these points easily. The established perennial broadleaf plant is hard to control because of the many buds on the roots, stems and crown.

BROADLEAF

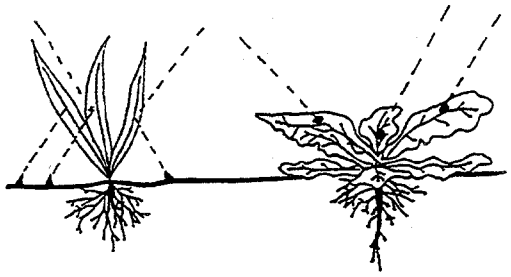


Seedling *Annual*
Perennial

PHYSICAL CHARACTERISTICS

Physical and species characteristics greatly affect the ability of herbicides to gain entrance in the weed. By considering each one, more effective control will be achieved.

LEAF SHAPE affects the amount of herbicide to be used. Herbicide sprays tend to bounce or run off of plants with narrow, vertical leaves. Broadleaf plants tend to hold the spray. If recommended on the label, add an adjuvant to increase spray retention.



WAX AND CUTICLE formation affects the absorption of the chemical by the weed. The herbicide must penetrate the leaf surface to be effective. A leaf with a thin cuticle allows the spray solution good contact with the leaf surface. On a leaf with a thick, waxy surface, the spray solution tends to stand up in droplets. The wax and cuticle are thinner on young weeds. This is another reason for applying herbicides at the early growth stage.

HAIRS on the leaf surface tend to keep the spray solution from entering. The droplets stand up on the hair and don't contact the leaf surface. Seedling weeds usually have fewer and shorter hairs. This is another reason for early control.

SIZE of the plant is another important consideration. Seedling weeds are easier to control than established weeds. As a plant increases in size and development, it becomes harder to control.

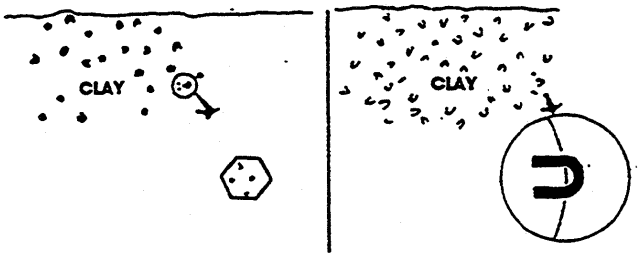
FACTORS AFFECTING SOIL-APPLIED HERBICIDES

HERBICIDE CHARACTERISTICS

SOIL PARTICLE TIE-UP

One of the properties of herbicides is magnetism. Some are not magnetic at all; others have strong magnetism. Those without a magnetic charge move down through the soil quickly. Others with positive magnetic charges tend to be tied up on the negative-charge sites of soil particles.

SOIL PARTICLE TIE-UP



Non-magnetic *Magnetic*

LEACHING is related to herbicide characteristics and soil factors. Herbicides and soils vary from non-leachable to completely leachable.

PERSISTENCE of a herbicide in the soil depends on herbicide characteristics, rate of application, soil texture, organic matter, precipitation, temperature, and surface flow. Herbicides can:

- Remain concentrated at the soil surface.
- Partially leach (diluting effect).
- Move through the soil in a front, allowing new weeds to grow above.

SOIL TYPE

Two factors affect the movement of herbicides that are applied to the soil:

- Texture of the soil -- how much sand, silt and clay the soil contains
- Organic matter in the soil

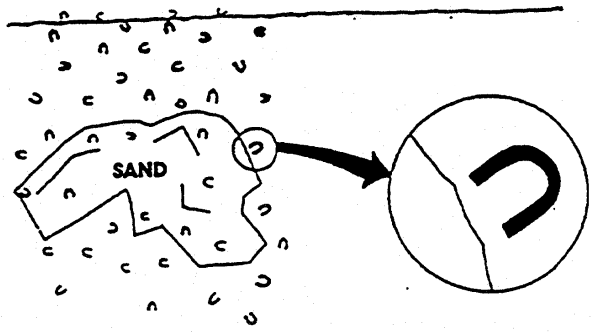
Texture

Sand is coarse and doesn't have many charge sites. The magnet-shaped particles are herbicide molecules moving down through the soil. The magnified circle shows the herbicide particle moving past the sand surface. It doesn't tie up.

Silt has more sites than sand but fewer than clay and organic matter.

Clay is fine and has many charge sites. The positively charged herbicide particle has fit into the negatively charged slots on the clay particle. It's tied up and won't continue moving through the soil.

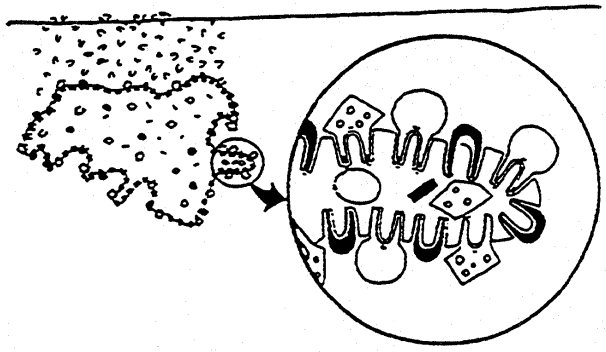
TEXTURE



Organic Matter

Organic matter has many more negative charge sites than even the finest particles. The magnified circle in the illustration below shows not only herbicide particles tied up on the organic matter, but also particles of other materials such as water, sodium, calcium and ammonia.

ORGANIC MATTER



ENVIRONMENTAL FACTORS

SOIL MOISTURE

Soil-applied herbicides must be in moist soil to be taken up by plant roots. This requires water in the form of precipitation or irrigation.

TEMPERATURE

Temperature determines the rate at which plants grow and are able to take up and translocate herbicides. At low temperatures, plants may not be active and won't take up the herbicides, or they may be so inactive that the herbicide works slowly. At very high temperatures, the herbicide may evaporate (volatilize).

HUMIDITY

A foliar-applied herbicide will enter the leaf more easily and rapidly at high humidity than at low humidity. At high humidity, the leaf is more tender and has a thinner layer of wax and cuticle.

PRECIPITATION

If rainfall occurs soon after a foliar-applied herbicide treatment, it may decrease effectiveness. Rain increases soil moisture, so soil-applied herbicides can be more readily absorbed by the weeds. But too much rain may move the herbicide too deep, past the zone where the weeds are. A hard rain may move surface-applied herbicides out of the target area. This is especially true if the soil surface is packed or sloping.

WIND AND TEMPERATURE

Wind and temperature can also affect the weed. A hot, dry wind will cause:

- The openings on the plant surface to close.
- The leaf surface to become thicker.
- The wax layer to harden.

These factors make it harder for herbicides to penetrate the leaves.

METHODS OF APPLICATION

Herbicides can be applied by three basic methods: (1) broadcast; (2) individual plant; or (3) spot treatment.

BROADCAST APPLICATION

Aerial and ground application to the foliage or soil is an effective method of treatment in large areas. Aircraft fitted with spray booms or dry spreaders and wheeled or tracked vehicles with spray tanks and booms are the major equipment used.

Each type of equipment has its own characteristics, and only trained, experienced operators should be used.

INDIVIDUAL PLANT
Treating individual plants can be used to control re-sprouts or to remove small areas of undesirable species. Individual plant treatments are usually done on woody plants, especially trees.

IN BASAL TREATMENT herbicides are applied undiluted or in oil or water to lower parts of stems and exposed roots. With some species, trees with trunks bigger than eight to ten inches across can be controlled with this method. Experience makes this method more effective. It's best to fell large trees, then treat the stumps immediately after cutting.

IN CUT-SURFACE TREATMENT herbicides can be applied to the sapwood through frills or notches. Frills can be made with an axe or chain saw. Another alternative is injection with specialized equipment.

STUMP TREATMENT is the treating of close-cut stumps and exposed roots with herbicides in oil. It's best to treat immediately after cutting. All sprouts must be treated.

SOIL-APPLIED HERBICIDES include those chemicals that are made to the soil around the base of plants. Generally, granular or pelleted herbicides are used. These must be in moist soil for results to occur.

SPOT TREATMENT
Treating small areas of undesirable plants can be done with hand sprayers, hand guns on large sprayers, and small dry-material spreaders.

DRIFT CONTROL
Be sure that the herbicides you use don't drift to non-target areas, either within the right-of-way or outside of it. There are two kinds of drift: particle and vapor.

Particle drift occurs when spray droplets are carried away from the application area by air movement. The distance a particle of herbicide spray can drift is determined by: (1) the force of the wind, (2) the distance from the spray nozzle to the ground, and (3) the size of the particle. The smallest particles, such as those in fog or mist, present the greatest drift hazard.

Vapor drift results from the evaporation of an active ingredient during or after application. The movement of such vapor with wind currents may injure sensitive vegetation. Vaporization isn't as common as particle drift, but it has more potential for moving a greater distance. To reduce the chances for drift, take the following precautions:

- Use the lowest practical pressures.
- Leave an untreated edge.
- Angle nozzles toward the ground.
- Use nozzles with the largest practical openings.
- Use low-volatile formulations of the chemicals.
- Spray when wind speed is low.
- Don't spray during a temperature inversion (when air is coolest at ground level, gets warmer up to a certain height, and gets cooler from that point on up).
- Spray when sensitive vegetation isn't actively growing.

DRIFT-CONTROL AGENT
Special adjuvants and application systems have been developed to help overcome some drift problems. Three of these are:

- Foams (tank-mixed, conventional formulation with an additive).
- Invert emulsions (three systems: mixed at nozzle, mixed at pump, or tank-mixed).
- Spray-additive stabilizer (thickeners in dry form mixed with conventional formulation in tank with agitation).

Though they differ in method, all three have similar advantages: better control of both particle drift and vaporization, and more highly visible spray, enabling you to see where you are placing it.

HERBICIDE APPLICATION EQUIPMENT

The equipment is of two general types: (1) airborne equipment, carried either by fixed-wing aircraft or by helicopter, and (2) ground equipment (including floating equipment on drainage-ways, irrigation waterways, and barge-ways), and railroad/roadside equipment.

Both airborne and ground equipment are available for applying conventional sprays (water, oil in water, and oil in oil), invert emulsions, and granular/pelleted formulations.

Rights-of-way have many obstacles that make the use of conventional spray booms difficult or impossible. The "manifold" sprayer (usually six nozzles with individual on-off valves, each set for different distances but with adjacent swath patterns) and the "handgun" sprayer nozzles are widely used. You also can get special equipment for applying herbicides to rights-of-way from aircraft.

Much special equipment has been developed for specific right-of-way jobs. It includes equipment for mounting on trucks, trailers, barges, rail vehicles, and all-terrain vehicles. The lack of a full range of well-adapted, readily available equipment for right-of-way spraying is becoming less of a problem.

Another difficulty in right-of-way application is the maintenance of a supply base. Because most rights-of-way are long and narrow, the operation continually moves away from its supply base. Return travel time is often excessive. Low application rates with minimum amounts of water or oil carrier make the job faster and more efficient, since it reduces the supply runs. Mobile supply
units are often needed. One unit, sprayer and supply combined, may be more efficient.

CLEANING THE SPRAYER

First rinse the sprayer with a material that acts as a solvent for the herbicide. Kerosene and fuel oils carry away oil-soluble herbicides such as 2,4-D ester. Chemicals that form emulsions when mixed with water are oil-soluble. After the oil rinse, a rinse with water containing detergent will help remove the oil. Oil-soluble herbicides are the hardest to remove. 2,4-D amine salts are water-soluble.

For most water-soluble herbicides, repeated rinsing with water is usually enough. Hormone-type requires extra precautions. If Banvel or 2,4-D was used, fill the tank with water and ammonia. Add household ammonia to 25 gallons of water. Pump enough solution through the hose and nozzles to fill these parts completely. Then fill the tank, close, and leave for 24 hours before rinsing thoroughly with water.

For materials like Oust, use chlorox. A three-percent suspension of activated charcoal can be used to absorb 2,4-D after the preliminary rinsing to decontaminate the sprayer. Agitate the suspension for two to three minutes and drain, then rinse thoroughly with clean water.

For wettable-powder herbicides, see that none of the powder remains in the tank. A thorough rinsing with water is usually sufficient. Thoroughly clean all equipment immediately after use. See the pesticide label for directions for cleaning the sprayer also.

ACCIDENTAL SPILLAGE OF RIGHT-OF-WAY HERBICIDES

In case of accidental spills, call the UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY at (801) 536-4123. Also notify local authorities, such as city and county police departments, and the Utah Highway Patrol. If in doubt on which number to call, dial 911.

Notify the National Response Center at 1-800-424-8802 or the Utah Poison Control Center at 1-800-456-7707.

UTAH DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WILDLIFE at (801) 538-4866 should be called if the spill contaminates streams or waterways.

PESTICIDE SPILLS

Pesticide spills can pose serious threats to human health and cause significant environmental contamination. A thorough knowledge of the steps to take in the event of a spill will allow you to minimize the potential for adverse effects and may save you a great deal of

money in expensive cleanup costs. Always be prepared to handle spills before they occur. Contamination can greatly increase when response to a pesticide spill is delayed.

CONTROL THE SPILL

Immediately after a spill has occurred, steps must be taken to control the flow of leaking pesticide. Do everything possible to stop the leak or spill at once! Leaking containers may be repacked. Leaking sprayers should be turned off immediately. Stopping large leaks or spills is often very hard.

CONTAIN THE SPILL

After the leak has been controlled as well as possible, contain the spilled material in as small an area as possible. With liquid spills, construct a dam to prevent the material from spreading. It's especially important not to allow any chemical to get into any body of water, including storm
sewers.

CLEAN UP THE SPILL

Follow the instructions given by the Utah Department of Environmental Quality to clean up the spill.

WEEDS ON RIGHTS-OF-WAY

Weeds on berms are unsightly; they harbor insects and diseases and cause cracking or deterioration along asphalt highways. Many times, a quick knockdown spray is needed if weeds are already growing, plus a more permanent herbicide to hold down weeds for one or more seasons. If such is the case, a combination of herbicides is needed. Applicators should read the label carefully for combinations that are compatible.

TREATMENT ON VACANT LOTS

Most cities and towns have laws requiring weed control on vacant lots to reduce the danger of a fire hazard. Pest-control operators should study herbicide activity as to residual amounts left in the soil. In most instances, a short-term control is best, such as one season or two seasons long. If the property is sold and homes are built, ornamentals can still be planted. There are several herbicides that can be used. A study should be made of all compounds, especially new ones on the market.

There are many soil sterilants labeled for use under asphalt, but they are intended for non-crop areas only. "Non-crop" also means non-landscaped areas.

BIOLOGICAL CONTROL OF WEEDS

Weed scientists are beginning to take a look at the potential of biological methods for the control of weeds. Under certain circumstances, this approach may be possible, although there are no methods discovered, up to now, which could be considered practical on commercial landscape sites or highway rights-of-way.

Insects with a feeding preference for specific weeds seem to hold the best promise. As this was written, 88 weed-feeding insect species have been introduced into the United States to control 43 species of weeds.

Recent work with plant pathogens has demonstrated their potential in weed control. For instance, a newly-discovered race of the fungus *Verticillium dahliae* has been found to attack seedlings of velvetleaf weed, *Abutilon theophrasti*, prevalent in the Midwest. Research indicates that the fungus remains with the host plant and carries over in the soil but doesn't attack crop plants.

GLOSSARY OF SELECTED TERMS USED IN WEED CONTROL

A

Absorption -- The process by which herbicides are taken into plants, by roots or foliage (stomata, cuticle, etc.)

Adsorption -- The adhesion of herbicide spray droplets to the plant's surface, soil, and organic matter.

Annual -- A plant that completes its life cycle within one year, then dies.

Aromatics -- Compounds derived from the hydrocarbon benzene (C_6H_6).

B

Band application -- An application of spray or dust to a continuous, restricted area such as in or along a crop row, rather than over the entire field.

Basal treatment -- Applied to encircle the stem of a plant above and at the ground such that foliage contact is minimal. This term is used mostly to describe treatment of woody plants.

Biennial -- A plant that completes its growth in two years. The first year it produces leaves and stores food; the second year it produces fruits and seeds.

Broadcast treatment -- Application of a herbicide over an entire field.

C

Carrier -- The liquid or solid material added to a chemical compound to facilitate its storage, shipment, or use in the field.

Compatible -- The quality of two compounds that permits them to be mixed without effect on the properties of either.

Concentration -- The amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.

Contact herbicide -- A herbicide that causes localized injury to plant tissue when contact occurs.

Cotyledon leaves -- The first leaf, or pair of leaves, of the embryo of seed plants.

Crown -- The point where stem and root join in a seed plant.

D

Directed application -- Precise application to a specific area or plant organ, such as to a row or bed or to the leaves or stems of plants.

Dormancy -- State of inhibited germination of seeds or growth of plant organs. A state of suspended development.

E

Emergence -- Appearance of the first part of the plant through the ground.

Emulsifying agent -- A material that facilitates the suspending of one liquid in another.

Emulsion -- A mixture in which one liquid is suspended in minute globules in another liquid -- for example, oil in water.

F

Foliar application -- Application of a herbicide to the leaves or foliage of plants.

Formulation -- (1) A herbicidal preparation supplied by a manufacturer for practical use, (2) the process, carried out by manufacturers, of preparing herbicides for practical use.

G

Granular -- A dry formulation of herbicide and other components in discrete particles that are generally less than ten cubic millimeters in size.

Growth stages -- (1) Tillering stage, when a plant produces additional shoots from a single crown, as in wheat. (2) Jointing stage, when the internodes of the stem are elongating. (3) Boot stage, when the seed head of a plant begins to emerge from the sheath (usually applied to grain crops).

H

Herbicide -- A chemical used to control, suppress or kill plants or severely interrupt their normal growth processes.

N

Non-selective herbicide -- A chemical that is generally toxic to plants without regard to species. Toxicity may be a function of dosage, method of application, etc.

P

Particle drift -- Spray droplets that are carried away from the application area by air movements.

Pellet -- A dry formulation of herbicide and other components in discrete particles that are usually larger than ten cubic millimeters.

Perennial -- A plant that lives from year to year for three years or more under normal growing conditions.

Persistent herbicide -- A herbicide that, when applied at the recommended rate, will harm susceptible crops planted in normal rotation after harvesting the treated crop, or that interferes with regrowth of native vegetation in non-crop sites for an extended period of time. (See residual herbicide.)

Plant-growth regulator -- A substance used for controlling or modifying plant-growth processes without appreciable phytotoxic effect at the dosage applied.

Post-emergence -- Applied after emergence of the specified weed or planted crop.

Post-emergence treatment -- Treatment made after the crop plants emerge.

Pre-emergence -- Applied prior to emergence of the specified weed or planted crop.

Pre-emergence treatment -- Treatment made after a crop is planted but before it emerges.

Pre-planting treatment -- Treatment made before the crop is planted.

R

Rate and dosage -- These terms are synonymous. "Rate" is the preferred term. Usually refers to the amount of active ingredient (such as 2,4-D acid-equivalent) applied to a unit area (such as one acre), regardless of percentage of chemical in the carrier.

Residual herbicide -- A herbicide that persists in the soil and injures or kills germinating weed seedlings over a relatively short period of time. (See persistent herbicide.)

Rhizome -- An underground stem capable of sending out roots and leafy shoots.

S

Selective herbicide -- A chemical that is more toxic to some plant species than to others.

Soil application -- A herbicide applied primarily to the soil surface rather than to vegetation.

Soil sterilant -- A material that renders the soil incapable of supporting plant growth. Sterilization may be temporary or practically permanent.

Spot treatment -- A herbicide applied over small, continuous, restricted area(s) of a whole unit -- for instance, treatment of spots or patches of weeds within a larger field.

Spray drift -- The movement of airborne spray particles from the spray nozzle beyond the intended contact area.

Stolon -- A runner or stem that develops roots and shoots at the tip or nodes, as a strawberry plant.

Stool -- To throw out shoots; to tiller.

Surfactant -- A material that, in pesticide formulations, imparts emulsifiability, spreading, wetting, dispersability, or other surface-modifying properties.

Susceptibility -- Magnitude or capacity to react to herbicide treatment. (See tolerance.)

Suspension -- A liquid or gas in which very fine, solid particles are dispersed, but not dissolved.

Systemic herbicide -- A compound that is translocated within the plant and that has an effect throughout the entire plant system.

T

Total vegetation -- Application of single or multiple herbicides at one time or in sequence to provide pre-emergence and/or post-emergence control of all plants. The term usually refers to non-crop areas.

Translocated herbicide -- A herbicide that is moved within the plant. Translocated herbicides may be either phloem-mobile or xylem-mobile, but the term is often used in a more restrictive sense to refer to herbicides that are moved in the phloem.

V

Vapor drift -- The movement of chemical vapors from the area of application. Some herbicides, when applied at normal rates and normal temperatures, have a vapor pressure high enough to cause them to change into vapor form. This may cause serious injury to susceptible plants away from the application site. Note: Vapor injury and injury from spray drift are often hard to tell apart.

Volatile -- The quality that makes a compound evaporate or vaporize (change from liquid to a gas) at ordinary temperatures on exposure to the air.

W

Wetting agent -- A compound that, when added to a spray solution, causes it to spread over and wet plant surfaces more thoroughly.

THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. This act requires EPA to ensure that these species are protected from pesticides.

Formulation of the Utah Threatened and Endangered Species/Pesticides Plan is a cooperative effort between federal, state, and private agencies and producers/user groups, and is a basis for continuing future efforts to protect threatened and endangered species from pesticides whenever possible. Furthermore, this plan provides agencies direction for management policies, regulations, enforcement and implementation of threatened and endangered species/pesticide strategies.

EPA has therefore launched a major new initiative known as the Endangered Species Labeling Project. The aim is to remove or reduce the threat to threatened and endangered species from pesticide poisoning. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides.The ESA is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The Fish and Wildlife Service will determine jeopardy to threatened and endangered species and report to EPA. EPA and FWS will work cooperatively to ensure that there is consistency in their responses to pesticide users and to provide necessary information. The Utah Department of Agriculture is acting under the direction and authority of EPA to carry out the ESA as it relates to the use of pesticides in Utah.

Maps will show the boundaries of all threatened and endangered species habitats in affected counties. The maps identify exactly where, in listed counties, use of active ingredients in certain pesticides is limited or prohibited. Product labels will be updated as necessary. The updated labels will reflect any additions or deletions to the project. Because EPA's approach to the protection of threatened and endangered species was in the proposal phase at the time this guide was published, any and all of the above information on threatened and endangered species is subject to change and may not be valid.

WORKER PROTECTION STANDARDS

This final rule, which was proposed in 1988 and which substantially revised standards first established in 1974, affects 3.9 million people whose jobs involve exposure to agricultural pesticides used on plants; people employed on the nation’s farms; and in forests, nurseries and greenhouses. The standard reduces pesticide risks to agricultural workers and pesticide handlers. The standard is enforceable on all pesticides with the Worker Protection Standard labeling. The provisions became fully enforceable in January 1995.

Agricultural workers in Utah now have a far greater opportunity to protect themselves, their families and others. These workers will know, often for the first time, when they are working in the presence of toxic pesticides, understand the nature of the risks these chemicals present, and get basic safety instructions.

Among the provisions of the rule are requirements that employers provide handlers and workers with ample water, soap and towels for washing and decontamination and that emergency transportation be made available in the event of a pesticide poisoning or injury. The rule also establishes restricted-entry intervals -- specific time periods when worker entry is restricted following pesticide application -- and requires personal protection equipment (PPE) for all pesticides used on farms or in forests, greenhouses and nurseries. Some pesticide products already carry restricted re-entry intervals and personal protection equipment requirements; this rule raised the level of protection and requirements for all products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training, which handlers have easy access to pesticide-label safety information, and that a listing of pesticide treatments is centrally located at the agricultural facility. Finally, handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

GROUNDWATER CONTAMINATION BY PESTICIDES

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination.

Formulation of the Groundwater/Pesticide State Management Plan is a cooperative effort between federal, state, and private agencies and producers/user groups; it provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement and implementation of groundwater strategies.

While it is recognized that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of crops, enhance outdoor activities, and give relief from annoying pests, the Utah Department of Agriculture is authorized by the U.S. Environmental Protection Agency (EPA) to enforce the protection of groundwater from pesticides. Product labels will be updated as necessary.

The Utah Department of Agriculture, in concert with cooperating agencies and entities, admonishes strict compliance with all pesticide labels, handling procedures and usage to protect groundwater in the state.

Groundwater can be affected by what we do to our land. Prevention of groundwater contamination is important, because once the water is polluted, it's very hard and costly to clean up. In some instances, it's impossible, especially if it is deep underground. City and urban areas especially contribute to pollution because water runoff which contains pesticides runs into drainage tunnels, then into a river or an underground stream which drains into the river. For more complete information about what groundwater is and where it comes from, read the study manual "Applying Pesticides Correctly." Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers. Sandy soils allow more pollution than clay or organic soils, because clays and organic matter absorb many of the contaminants.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establishes a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, a pesticide can be registered by the EPA. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that is not degraded or broken down and carry it to the groundwater via leaching.

The major factors which influence the amount of contamination which can get into water are the chemicals' persistence in soil, retention time or time it remains in the soil, the soil type, the time and frequency of the application(s), soil moisture, placement of the pesticide, and the ability of the chemical to persist once in the aquatic environment. Each of these factors will influence the amount of pesticide which can leave the root zone or soil surface and percolate to groundwater.

Although some pesticides may have a high absorption quality, when they are applied to sandy soil, they will still migrate to the water table because there are no fine clay particles or organic matter to hold them. The management and use of pesticides is up to the individual applicator and/or land owner as to whether safe practices are used. Water is one of our most valuable resources; we must keep it as pure as possible.